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The accompanying Report on "Cocoanut Palm disease in Travancore" by Dr. E. J. Butler, M.B., F.L.S., Imperial Mycologist, published by the Agricultural Research Institute, Pusa, is hereby republished for general information.

By Order,

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REPORT ON COCOANUT PALM DISEASE IN TRAVANCORE.

The southern half of the cocoanut forest of the Malabar coast lies in Travancore. Viewed from the sea near Alleppey it forms a continuous belt in which the coast villages are entirely buried. The coast line here consists of a sandy beach, passing inland into a light soil with a large proportion of sand until the shore of the Vembanad lake, a large lagoon some forty miles long, opening to the sea at Cochin, is reached.

This lake forms part of the continuous system of navigable lagoons and channels, part natural part artificial, which extend parallel to the sea for a distance of over two hundred miles northwards from Trivandrum. These are for the most part narrow and tortuous but open out here and there into expances of shallow water, the whole forming an unrivalled chain of "backwater" communication through the heart of the cocoanut area.

Around the lagoons and backwaters the soil is stiffer than along the coast, largely formed of silt taken from the bed of the water channels and employed to build up small islands and banks, raised a foot or two above the water level, crowded with cocoanuts and densely populated. In parts of the east and south-east of the Vembanad lake low ridges of laterite are found. In this tract between the sea and the backwaters and around the latter, except on the laterite, the best cocoanut lands of North Travancore are found.

Practically only two types of cultivation are seen in this area. By far the larger portion consists of cocoanut gardens, with areca, jack, plantain and other garden produce as subsidiary crops. In the shallow stretches of water, broken by cocoanut topes, which border the lake and open out of the backwaters, a peculiar type of paddy cultivation is seen. These stretches are enclosed by mud and wattle bunds built from the bed of the lake to near the surface of the water in the monsoon, and the surplus water is pumped out by steam or hand power, until a crop of paddy can be put in. The pumping is done after the North-East Monsoon, the crop planted about December and harvested just before the inundation of the following South-West Monsoon.

Inland from the backwaters is a tract of country extending to the foot of the Cardamom hills, which form the western half of the State. This is broken by numerous rivers and streams descending from the hills to empty into the backwaters and ultimately the sea. It is not flat, like the coast belt, but diversified by low hills and ridges, particularly towards the higher range. Cocoanut cultivation follows the rivers and streams, the palms being found not only in the valleys but also on the hill sides.

It is possible, therefore, to distinguish three more or less distinct zones of cocoanut cultivation; the littoral with sandy soil not much raised above the water level and comprising the largest part of the area under cocoanuts: the part adjoining the backwaters, equally lowlying but with soil largely formed of silt: the sub-montane, extending inland to the foot of the hills, with a deep red or blackish alluvium along the valleys and a shallow, generally poor, laterite on the hills. The palm thrives best on the sand of the coast and the sandy loam around the backwaters within ten or fifteen miles of the sea. Towards the hills it is less productive; fine gardens occur in the valleys but those on the hill sides are poor.

The climate of Travancore is remarkably equable all the year round. The mean day temperature of the year is about 80° F., the mean maximum of the year about 87·5° F, and the mean minimum about 75° F. Higher readings than 90° are rare, and lower than 70° still rarer.

The rainfall shows two well-marked progressive increases from south to north and from the coast-line to the hills. Thus it increases from an annual average of 30 inches near Cape Comorin in the south to 114 inches at Alleppey and 117 at Parur in the north of the State, and again from 114 inches at Alleppey on the coast to 198 at Peermade in the hills. There is no long dry period, rain falling as a rule every month throughout the year, though December to March is comparatively dry. January is the driest month. Precipitation increases until the arrival of the South-West Monsoon. June is the month of maximum rainfall. Then there is a diminution again until October when, with the North-East Monsoon, a secondary maximum is reached.

As the cocoanut is said everywhere to require a warm and moist climate with an equable temperature it will be evident that Travancore fulfills its climatic requirements perfectly. It is

said also to flourish best sufficiently near the sea to allow of the sub-soil being infiltrated with sea water. Different analyses in India, Ceylon and the Philippine Islands seem to show that a heavy crop removes over a hundred pounds of potash salts and over sixty of sodium chloride (common salt) per acre per annum, and may explain this preference. Be that as it may a large proportion of the best Travancore cocoanuts are in soil which is infiltrated with salt or brackish water.

That this salt is a necessity to the tree is evidently believed in many cocoaunt growing countries where, as in Travancore, an application of salt to its roots is frequently made. Its requirements in potash and magnesium are probably supplied in part by infiltrated sea water in lowlying littoral or backwater soils. Elsewhere they are furnished by dressings of wood and leaf ashes (largely of the cocoanut itself) applied around the base of the tree. Beyond this a limited amount of manuring with cocoanut or other *poonac*, cattle manure, fish manure and, occasionally, bones is practised. The palm responds remarkably quickly to fertilizers and there is certainly much room for improvement in indigenous practices in this respect.

The prosperity of Travancore—admittedly great—depends primarily on its cocoanut industry. It is difficult to ascertain the exact area under the palm, combined as it is with every other sort of cultivation except in the dry area of the south, on paddy lands, and in the hills. One estimate gave about 250,000 acres under palms. The exports for 1903 were approximately a crore of rupees' worth of all kinds of cocoanut produce, oil, copra, coir, and nuts. The internal consumption is very great. Aprat from those actually engaged in palm cultivation, land-holders, tenants, labourers, etc., the coir industry alone supports 133,047 persons, according to the census of 1901. One of the densest populations in India (six of the Taluks have over 1,000 persons to the square mile and three over 1,300) is maintained primarily by this palm. It is natural that any diminution of yield due to disease should have forced itself on the notice not only of the cultivators but of the State authorities. Still it is an indication of the insidious nature of the attack of the disease here dealt with that, though Minachil has been affected for thirty or forty years, it does not appear to have been brought to the notice of Government until much later, in a memorial from the ryots of Kaviyur and Kalloopara, dated April 24th, 1897. Even yet the serious state of affairs is not realised in many localities where it is considered a passing affliction, though the experience of the older affected localities, such as Minachil, should serve as a warning.

The extent of the damage already caused by this disease may perhaps be gauged by the fact that, in spite of the rise in prices in recent years, the trade in cocoanut produce accounted only for 32 per cent of the entire State exports in 1905-06 against an average for decades past of nearly 50 per cent.

In the short time at my disposal I was unable to ascertain the exact limits of the area said to be affected by the disease. It is confined to North Travancore; from North to south it extends from Shertollay to probably near Quilon; inland it reaches the foot of the hills at Erattupetta. The total area affected is, however, unknown.

The earliest record of the outbreak that I could obtain was at Erattupetta in Minachil Taluk. Here it was variously stated to have commenced thirty to forty years ago. In so remote a period the cultivators' recollections are likely to be mere approximations; still it is certainly of more than thirty years' standing. From Erattupetta it spread slowly westwards to the adjoining villages, Minachil, Lalam and Pulliyanur. The latter is said to have first got the disease about twenty-five years ago. Further to the west it is still spreading slowly in a continuous line; a village about seven miles west of Pulliyanur was, I was told, reached only two years back At the same time outbreaks occurred in many other parts of North Travancore At Changanachery I was told it had been noticed about twenty years ago, but some gardens have been attacked within the last two years. At Alleppey, where it is confined to a small area, it was also first observed about twenty years ago. In each case after the first outbreak in one garden, neighbouring gardens have been successively attacked, and everywhere seen there were the same indications of gradual spread from one or a few original centres of infection.

Besides cocoanut several other species of palm are attacked. The areca palm is even more severely affected at Minachil, and opinions were unanimous there that this was the first variety to become diseased. The talipot (*Corypha umbraculifera*) is not nearly so common as these two, but several cases of disease in this palm were brought to my notice. Similarly the sago palm (*Caryota urens*) is sometimes affected. I heard of no case in palmyras. In the others the symptoms are alike, and there is no reason to doubt that all suffer from the same disease.

The symptoms are those of a slow and progressive deterioration of the palm, in sharp contrast to the rapidly fatal palm disease of the Godavari Delta on the east coast. They are not always developed in the same order and some, such as an exudation of gum from the trunk, are only occasionally found.

As a general rule the first indication that a cocoanut palm is attacked is the opening out of the outer leaves from the head. The leaf stalk becomes slightly flaccid and the weight of the leaf causes the whole to droop. Then the ends of the pinnae or leaflets at the extremity of the leaf become flaccid and hang down almost vertically. This is accompanied by a loss of colour; the drooping and discoloration of the leaflets then extend gradually backwards to the whole leaf. Later on the tips of the leaflets turn yellow and dry up, followed gradually by the entire

leaf, which eventually hangs down withered from the crown. The attachment of the leaf sheath to the tree is weakened so that the outer discoloured leaves can be easily torn of from the crown. One after another, or many together, all the leaves are similarly affected; intermediate conditions are common; young trees often have a large proportion of leaves healthy with only a few yellowed, others have all the leaves equally discoloured and drooping at the tips of the leaflets, before any dry up. Gradually, as the palm weakens new leaves that are put out are smaller than of old. This is apparent even before they unfold from the bud and results in the central or leading shoot, which is merely the unopened new leaf bud, becoming stunted and pallid. Later on it begins to wither and the upper free part turns brown. Eventually it may dry up altogether, but this may not occur for many years.

Even in the first year or two the nuts are affected. They are fewer and smaller than usual. On splitting the husk is found unaltered and usually the shell also. The white kernel is however, shrivelled and indurated and copra prepared from it is said to be deficient in oil. The fluid inside is reduced in quantity (or even, I was told, sometimes absent, though I did not see any such case) and is altered in quality, becoming unpalatable to drink. In later stages a large proportion of the nuts drop in an immature condition. In more severe cases the spathes are unable to burst out at all or, if they do, rot away early and the palm becomes barren.

In healthy palms a bunch of nuts is given about every two months. The best trees in the sub-montane districts yield about 60 to 80 nuts a year. Nearer the coast the yield may rise to 80 or 100, though the average is much lower. I was shown one fine palm that gave, up to a year or two ago, an average of twenty nuts per bunch; it is now diseased and gave this year only three or four.

The top of the stem and the white internal part of the crown (known as the "cabbage") are quite normal, except in old cases, just before death, when the latter rots. Even in severely affected palms no trace of the disease or of any unhealthy condition can be found in these parts. The rest of the stem is equally healthy in appearance; I was told that wood from diseased trees is weaker than that from healthy, and it is certainly more spongy in texture. In some cases cracking of the rind with exudation of gum occurs in the early stages; it is not a general symptom but only seen in a few cases. As in palms everywhere, discoloured patches on the rind are frequent, but they are mostly superficial and entirely unconnected with the disease. A brown discoloration frequently appears after cutting open the trunk. This is apparently more marked in diseased than in healthy trees. It is not visible when first cut, is quite unconnected with any parasite, and is probably due to an oxidation process.

The absence of any parasite in the stem is of interest. A cocoanut disease, similar in many respects to the Travancore disease, has recently engaged attention in Ceylon. It has been attributed by the Government Mycologist, Ceylon, to a fungus known as *Thielaviopsis ethaceticus*, well known as the cause of the "pine-apple disease" of sugarcane. A similar fungus occurred with such regularity on the cut stems of cocoanut palms wherever examined in Travancore, that the likelihood of its being the cause of the disease appeared considerable. Further investigation showed that this is not the case. The fungus, though allied to the cause of "pine-apple" disease, is a distinct species of *Thielaviopsis*. It occurs equally on healthy and diseased palms, and on all or most of the Indian species, being common on cocoanut, areca, palmyra and date. It is found on cut surfaces of roots, stem and crown and appears freely on split areca nuts that are perfectly healthy. Hence its spores must be very widely distributed on the surfaces of palms, and in the air in palm-growing tracts. As it lends itself eminently to rapid dissemination this fact alone would be enough to put it out of court as a cause of the disease, for the progress of the latter is extremely slow. Even more definite evidence is fortunately available. It occurs equally freely on palmyra and date palms at Pusa where no serious palm disease is known. It has also been encountered in Sylhet on areca palms, in the Godavari on palmyra and cocoanut, and on date palms from Sind. In none of these areas is there a similar disease to that in Travancore. Further, slabs of the stem of deceased cocoanut palms in Travancore were cut out with a red-hot knife under asceptic precautions, and incubated. These did not give rise to any fungus when kept from exposure to the air, though when uncovered they quickly showed a characteristic growth of *Thielaviopsis*. Hence, whatever be the cause of the Ceylon disease, the palm *Thielaviopsis* is a perfectly harmless fungus in India, so far as is at present known, and certainly has nothing whatever to do with the Travancore disease.

After the leaves, the most extensive alterations are found in the roots of the diseased palms. As the roots themselves show differences in the sandy soils of the littoral tract and the heavy alluvium of the inland valleys they will be separately described.

In the sandy soils of the coast and the light silts of the backwaters the main roots extend both downwards and laterally for great distances. For most of their course they are unbranched, finger-like structures, covered with a reddish bark, usually straight and gradually diminishing from three-quarters of an inch or more to half an inch or less in diameter. From their structure they must be considered to be primarily "fixing" roots, whose chief function is to fasten the tree into the soil. Water and food supplies taken in by the feeding roots must pass to the stem through them, but it is improbable that they themselves play any part in obtaining supplies. From these main roots the lateral roots are given off at intervals, and from the lateral roots finer rootlets arise. The roots of the second and third order are small, white,

softer and less brittle than the main roots and appear to extend only a short way from the parent root. Food and water are taken in by the finer rootlets, which thus have functions of the highest importance in the economy of the tree.

In the heavy alluvial soils of the sub-montane area the roots do not run to anything like the length of those in sandy soils. The main roots are smaller, much curved and twisted and frequently branched. The lateral feeding-roots are given off closer together and are better developed than in the other case.

In the sandy soils food supplies are scanty. As a result an effort is made by the tree to tap as large an area as possible. It can hardly be doubted that this is the explanation of the long exploring roots of palms in the littoral tract. The valley soils of the interior are, on the contrary, rich in organic matter washed down from the hills, and food is present in sufficient quantities near the base of the stem. Hence there is no need for the penetration of a considerable bulk of soil and the roots mass and ramify in a comparatively small space.

In consequence of the larger expanse of root an examination of the entire root system of any but seedling palms is practically impossible in the sandy area. The following account is, therefore, based chiefly on conditions observed at Pulliyanur in deep valley soils; such examination as was possible at Alleppey on the coast was only sufficient to show that the essential features are the same.

In seedling cocoanut palms the main roots arise densely crowded together from all parts of swollen base of the stem, and diverge in every direction. Each main root gives off numbers of white lateral roots, which again give off others of the third order. Except in advanced cases of disease, the main roots of a diseased tree will be found for the most part unaltered. A large proportion of the lateral roots are however rotted and, in some cases, this rot extends back into the main roots and even to the base of the stem. In some advanced cases of disease half of the main roots were found to be affected with this rot while the proportion of the smaller roots rotted was much higher. In milder cases only three or four main roots may be rotten while, even on the sound roots, perhaps fifty per cent of the rootlets will be dead.

The disease, therefore, manifests itself chiefly through alterations produced in the leaves and in the roots and it is necessary to ascertain in which of these parts it has its original seat.

In the leaves the wilting and discoloration of the leaflets are not induced by parasitic attack. The leaf tissue simply gets pale and flaccid. Even when this extends to the whole leaf there is still no indication of any local parasite at work. The condition is merely one of starvation and drought. When the leaf ends die, no doubt fungi appear, but fungi always fasten on any dead plant tissue and an examination of those found showed that they were common moulds and harmless species, feeding on the dead tissues.

The minute plants known as fungi are, as a whole divided into two classes according to their food requirements. The larger class, the *saprophytes*, live on dead organic matter, chiefly plant remains; they cannot get their food from living tissues such as growing plants. The smaller class, the *parasites*, are on the contrary able to attack and feed on living tissues, and are the cause of a vast number of diseases of plants.

On the leaves of diseased palms no parasite was commonly found, such as would be sufficient to account for their unhealthy condition. Were one present we would expect to find the first attack confined to one or several small areas, whereas in fact a large number of leaves may turn yellow and all their leaflets begin to droop simultaneously.

In the roots matters are different. The root itself consists of an outer layer of thick-walled cells which form a protective covering. Within this there is a zone of variable thickness, composed of cells with moderately thick walls which become larger, looser and have thinner walls as they are further from the surface. This is known as the *cortex*. Within the cortex, and forming the central tough strand of the root, is a body of mostly thick-walled cells, called the *central cylinder*. It is through the latter that the vessels run which convey water and food salts from the soil to the stem.

Lateral roots affected by the rot mentioned above are invaded by a parasitic fungus, which enters from the soil and develops the minute threads, of which its body is composed, in and between the cells of the cortex. When a root becomes invaded by this parasite the cortical cells are killed as soon as a thread of the fungus reaches them. They quickly turn brown and collapse. This is especially marked in the large thin-walled cells of the inner layers. At a later stage the whole root appears blackened and shrunken as a result of the death of a large number of its cells; it can evidently no longer perform its work of taking in food and decomposition rapidly sets in.

The threads of the parasite are of two kinds. The older ones are deep brown and comparatively large. From them arise finer colourless branches. All are divided into segments by transverse walls. In older stages masses of these brown threads become crowded together and divide frequently, so that a brown patch of fungus tissue is formed. In this, at a still later stage, spore-capsules are developed under the rind and these burst out to open on the surface of the root and discharge spores. The spores are rather large, egg-shaped bodies, colourless and single when young but divided into two cells and deep brown when older. It is a species of the genus *Botryodiplodia*, of which several parasitic members are known.

Quite recently Mr. F. A. Stockdale, Mycologist to the Imperial Department of Agriculture, West Indies, has described a similar and perhaps identical species as the cause of a serious cocoanut disease in Trinidad. The symptoms of this disease are on the whole similar to those described above and it appears to be possible that both are really the same.

There is no absolute proof that the *Botryodiplodia* is the cause of the disease, either in Travancore or in Trinidad. It is not even certain that the two are identical, as the scientific description of the latter has not been published. So far as can be gathered from Mr. Stockdale's report the spores of his fungus were not found actually on cocoanut roots, but only on the leaf petioles, though he attributes the death of the roots to a fungus found in them and apparently agreeing with that on the petioles. In Travancore the *Botryodiplodia* was only found on roots, but was obtained on deceased roots of areca as well as cocoanut palms. Spores were not found on roots actually in the soil, but developed on diseased roots after these had been dug up and kept for some time. Only the early stages of formation of the spore-capsules were found in freshly dug roots. The brown threads within the roots were found in these cases to communicate with the spore-capsules, both immature and ripe, and there is no doubt that the threads of diseased roots belong to the *Botryodiplodia*.

Scientific proof that this fungus is the cause of the disease can only be obtained by inoculating the roots of healthy palms with a culture of the fungus, and thereby producing the disease. This has not been possible in the time at my disposal, and would require facilities for isolating and growing the fungus which were not available in Travancore. All that can, therefore, be safely said is that the roots of diseased palms are rotted by the attacks of a parasitic fungus; that this fungus appears to be a *Botryodiplodia*; and that probably the root rot caused by it is sufficient to produce the disease at present ravaging the cocoanut gardens.

The effects of such a parasitic attack on the roots will be at once clear if we consider the work which healthy roots have to perform. For healthy growth a tree requires a supply of carbon dioxide and oxygen from the air, and water with dissolved salts from the soil. The latter are useless to the plant until they are carried up to the leaves, where they become transformed into food. For this purpose a steady flow of water, containing the salts in solution, must be maintained between the roots and the leaves. The surplus water at the top is got rid of by "transpiration" or evaporation into the air. Besides its use in carrying salts to the leaves, an abundant supply of water is required in every part of the plant body to keep the body cells in activity.

All the water required by a plant is taken in by its roots. The roots which do this work are for the most part not the main roots but the finer rootlets. As we have seen above a large proportion of these are found to have rotted in diseased trees, with the result that the water-supply is diminished. In a tree such as the cocoanut palm the effects of this would naturally not be evident in the stem, but would be visible first in the leaves. This accounts for the early symptoms of drooping of the leaflets and flaccidity of the leaf stalk so that it bends away from the crown. At the same time interference with the food supply causes the leaves to lose colour. The yellowing of the crown, which is most evident symptom of the disease, is thus due to the combined effects of drought and insufficient food. Hence, it is that though an appearance of recovery is said to be frequently visible after heavy rain, the effect, as it is only due to a temporary increase in available water, disappears as rapidly as it came.

The period of fruiting of any tree throws a heavy additional strain on its resources. This is chiefly in the matter of food supply. Hence, unless the feeding mechanism of the tree is in perfect order the fruit is not properly developed. For the first season or two of scarcity the reserve resources possessed by every tree may be sufficient to allow a fair proportion of fruit to ripen. This, however, is only done at the expense of the "capital" of the tree and in reality hastens its deterioration. Later on food becomes insufficient for any formation of fruit and the tree becomes barren. This is exactly what happens in cocoanut disease; it is made manifest first by a diminution in the number of nuts on each bunch, then by their dropping while immature and finally by their entire absence.

As a larger number of leaves become incapable of performing their proper work of manufacturing food the leading shoot becomes stunted. The still unexpanded leaves of the bud turn yellow and dry up at the extremities. This withering extends backwards until, in extreme cases, the bud itself withers, rotting sets in and the crown falls off. Such a termination may not be reached for years; localities such as Alleppey, where disease has existed for twenty years, have as yet had comparatively few deaths.

Palms of every age are attacked. In Minachil numbers of diseased seedlings, a year or two old, were found. Very old palms appear to escape longest, probably on account of their large root area. Still I saw a few trees, said to be about a hundred years old, which were undoubtedly diseased.

The intensity of the disease differs greatly in different localities. In the sub-montane area around Minachil death is a frequent termination. In Alleppey and Changanachery deaths are rare. In the former the attack first began in areca palms and subsequently extended to cocoanuts. It spread most rapidly and is still most severe in the lowlying, badly drained lands along the valley of the Minachil river. Gradually the hill side gardens were attacked, until at the present time scarcely a garden between Erattupetta and Pulliyanur is free from it. In

areca palms it runs its course more rapidly than in other species. This is probably due to a variety of causes. In the first place there is little or no attempt at cultivation in the areca gardens. The nuts are self-sown and come up densely through a heavy undergrowth of weeds. They appear to receive little attention at any period of their growth. The palms are very close together six or eight hundred to an acre. They are smaller and probably more delicate than the cocoanuts. All these circumstances favour the disease and it spreads rapidly once it gets a footing. In one garden visited, only thirty areca palms had survived out of six hundred. Death has been known to occur in three years from the first attack, but the usual period is five or six years.

In cocoanuts young palms may be killed in five years, but this is exceptional. Eight or ten years appears to be a more usual period, while in very many cases the disease progresses enough to cause barrenness, but fails to kill the tree outright. Thus, in one large garden only two hundred cocoanut palms were in bearing out of about two thousand, while the actual deaths were not numerous. Recovery in either areca or cocoanut palms, once they have taken the disease, is said to be unknown near Minachil.

Near the coast at Alleppey very few trees have been killed. The area affected here is an almost continuous block of about twenty-five acres in extent. In part of this some proprietors have seventy or eighty per cent of their palms diseased. Here cocoanuts were first attacked and areca palms, which are less grown, subsequently. I was shown several palms which have been diseased for more than ten years without succumbing. As regards recovery opinions were conflicting. In some cases a progressive recovery lasting for five or six years was said to have occurred. Others said that such recovery was temporary and that the palm never succeeded in entirely throwing off the infection. At Changanachery in the backwater tract the disease was similarly of a mild type as compared with Minachil but was widespread. Deaths were rare but the loss in yield in individual gardens was over fifty per cent. A temporary recovery had been obtained by one man, who applied lime to the roots; this only lasted for about two years and the yield again dropped. Here, as at Minachil, lowlying lands were most severely attacked, but gardens on higher lands were not immune. Where the soil is sandy the progress is slower than on laterite.

The above account shows that the disease is worst in the heavy alluvial valleys and poor laterite hill soils of the sub-montane tract. It is widely distributed but less severe in the neighbourhood of the backwaters, being apparently worst on poor laterite ridges and badly drained hollows. It is least severe on the sandy soil of the littoral.

Spread has probably occurred from one or a few centres which were early attacked. The evidence points to Minachil Taluk as the locality of its first appearance. The extension in this Taluk has been continuous from Erattupetta towards the west. At the same time other outbreaks occurred in isolated places, such as Alleppey. The question of the infectious nature of the disease is therefore of great importance since, if it has succeeded in crossing the Vembanad lake, there appears to be no reason why it should not eventually spread all along the Malabar coast.

The disease is undoubtedly infectious. All the evidence points that way. For instance the steady gradual extension from east to west in Minachil Taluk can have no connection with conditions of soil, climate or anything of that sort; it must imply the march of some infectious matter. Similarly the small deceased area at Alleppey is gradually extending but forms a solid block, while to the north, east and west there is none for miles. The best evidence, however, was got in a garden about half a mile south of the main area of decease at Alleppey. About ten years ago a palm was purchased from a garden in the latter area and transplanted into this garden. It was diseased at the time but the purchaser did not at once realise this fact. None of his other trees were in any way unhealthy at that date. Some few years after, however, the palm next the newcomer began to turn yellow, and this was followed by others near by. Now there are thirteen palms affected all near together, while the original one has died and been removed. It has not remained confined to this garden but some five or six others adjoining have each a few cases of disease. There can be no possible doubt that the infection of this locality was the direct result of introducing a diseased tree and planting it amongst healthy ones, and the owner himself firmly believes this.

The practice of transplanting palm trees is apparently not rare. If a site has to be cleared for building a house, the palms occupying it are frequently sold by auction. Even large trees are said to be purchased in this way, and are removed with a mass of soil around the roots to a new locality. Where a root disease exists nothing could be more dangerous than this practice, for the infectious matter is introduced into healthy soil and gets a strong footing there.

How the disease has reached palms situated at a distance from its original starting point, without affecting those in between, is not clear. There must be few parts of India with a greater internal movement of population than Travancore, judging from the boat traffic on the backwaters and into Alleppey. It appears probable that the germs of disease have been conveyed from place to place by water, either on raw cocoanut produce or in some other of the many conceivable ways. It must be remembered that the transport of a small quantity of soil or a few cocoanut roots from a diseased to a healthy garden might readily lead to infection of the latter.

It appears probable that no other means of spread exists than from root to root through the soil. Many fungus diseases of plants are disseminated by spores blown through the air. A well known instance of this in Travancore is the coffee leaf-disease. Such blights are characterised by the rapid way in which they spread over the whole of the country where conditions favourable for their existence occur. Every coffee-growing part of South India was attacked in the few years following 1869 when leaf-disease first appeared. It is evident that the greater part of North Travancore is suitable for the growth of the cocoanut root parasite, since outbreaks have occured in so many localities. Hence the slow spread of the disease and the fact that many parts of the coast belt have not yet been affected suggest the absence of air-borne infection. The parasite has only been found on roots below the soil level and, even if spores are formed, they could not easily reach the air. Extension through the soil, however, almost certainly does occur and is practically the only way in which the conditions described above, as found at Alleppey, can be explained.

The spread of a fungus in the soil depends a good deal on soil conditions. Cultivation hinders it, owing to the disturbance and consequent aeration of the upper layers of soil. Imperfect drainage is frequently found to intensify root diseases, probably both because sodden soils allow a more active growth of the parasite and because root development is less in such soils. Drought probably injures both parasite and host-plant, but the latter most, as its damaged root system cannot cope with the demand for water unless moisture is plentiful. In the dry season the leaf symptoms in the Travancore palm disease are at their worst, but a severe drought, which would probably cause a heavy mortality in diseased palms, is not likely to occur in North Travancore. In the whole the evidence is that heavy, ill-drained lands suffer most. In these, especially in clay soils, the growth of the roots is checked; those that rot away are not readily replaced by new ones; the attempt is made but the new roots are feeble and unhealthy from the start.

The most difficult of all fungus diseases to check are those which affect the roots of plants. The parasite which is the probable cause of cocoanut disease in Travancore enters into the tissues of the living roots and is out of the reach of any direct treatment. No ready cure can, therefore, be looked for. Any application which would kill the parasite must be taken up by the roots; with few exceptions these would also kill the roots and do more harm than good. There are other methods however by which—we may hope to lessen its ravages and these will be considered in order.

1. *The eradication of the disease by destroying all diseased material and so preventing infection of healthy palms.*—This is the method which is being employed in the palm disease prevalent in the Godavari District of the east coast. In the latter, however, the limits of the disease are well defined and are not very extensive. The disease itself is confined to the "crown," and if this is cut off and burnt all infective matter can be destroyed. In Travancore the disease is scattered throughout a much larger area than in Godavari. Much greater numbers of individual palms are affected and, even were the disease confined to the crown of the tree, it would be a work of great magnitude to attempt to eradicate it by burning all diseased crowns. As in fact such a measure would be useless unless the roots of diseased trees were also dug out and burnt, this method appears to be entirely out of the question as a general procedure.

In a certain number of cases the method of eradication can, however, be adopted. When disease first appears in a new locality there should be no hesitation in applying it. A large number of individual outbreaks appear to have occurred in parts not immediately adjoining a previously diseased area. All Taluk officers should be instructed to watch for the first appearance of disease in any part of their charge not bounded by a diseased area and to take prompt steps to have diseased trees dug up and burnt. There will be many difficulties in the way in carrying out this suggestion. Newly affected palms continue to yield for some years. The owners will naturally oppose their destruction as long as there is a prospect of obtaining any crop from them. This feeling can be lessened if it is pointed out, by means of widely distributed vernacular leaflets, that the disease is infectious and that measures to prevent its spread are undertaken in the interests of the raiyats themselves. If detected in the early stages probably only a few palms will have to be destroyed. Even if a whole garden or a small group of gardens is found to have the disease, the interests of the few should be sacrificed to those of the many whose gardens are still free.

In considering this method of attacking the disease it must be clearly borne in mind that there are two quite distinct sets of circumstances. In the first place there are large and continuous areas of disease such as that in Minachil Taluk, at the margin of which a steady continuous extension is going on. It is questionable if any drastic remedy, such as removing newly diseased trees, is practicable along the margin of such areas. It is probable that nothing short of clearing a belt of palms in front of the disease would prove effective; reinfection from the diseased area would be likely to occur, as long as any healthy palms remained near by. I am not inclined to suggest so large an undertaking. In the second place there are numerous isolated outbreaks occurring away from previously diseased localities. These, if detected early, can be dealt with by the method of extermination at comparatively small expense and with a loss that will be repaid many times over by the palms thereby preserved. Diseased palms of all kinds—areca, cocoanut, talipot, sago and possibly palmyra (if it should be found to

get the disease)—should be removed. After digging out the roots the hole should be well limed and the earth turned over at intervals for a period of about a year to destroy any remains of the fungus. Replanting can then, in all probability, be safely undertaken.

Only the root and base of the stem below ground need be burnt. After digging up they should be split into pieces if necessary, and built around with plenty of dry palm leaves or something of the sort to give an intense heat when fired On no account should the excavated roots be left lying about, for there is a danger of spore formation taking place on the surface and consequently of dissemination through the air. They should be burnt within a few hours of removal.

I believe that it is only by the most energetic action in this direction that there is any chance of checking the spread of the disease to hitherto unaffected parts. Every new localized outbreak serves as a focus from which a gradual but apparently inevitable spread takes place. No part of North Travancore is immune, and it appears to be merely matter of time before the whole area becomes attacked. The outbreak at Alleppy shows that even the coast belt does not escape, and there has been no diminution but, on the contrary, a steady progress there for the past twenty years. The area now affected (about twenty-five acres) is sufficiently defined to make it a good test case of the value of total extermination. If compensation were necessary the amount would not be excessive. At the same time the few gardens affected at Mukolakal, a little distance to the south, should be similarly dealt with; careful search should also be made for any other similar outlying cases.

The questions of compulsory action and compensation do not appear to call for discussion in this report. It is, however, probable that some form of compulsion would be necessary in carrying out the above suggestions.

The staff that would be required and the manner of their recruitment must also be left to the State authorities to consider. Probably the best method of ascertaining the actual requirements would be to depute an officer to make special survey of the diseased Taluks in North Travancore. In this all localities which appear to have been recently infected, or where the disease is confined to a limited area as at Alleppey, should be shown, the distance from the nearest large area of disease indicated and a rough estimate made of the area requiring to be dealt with. To assist in an enquiry of this nature a short description is given below of several other minor causes of ill-health in cocoanut palms noticed in Travancore, sufficient to enable them to be distinguished from the root disease.

2. *Ridding infected soil of the parasite in order to allow of replanting.*—After removing all diseased palms from an infected spot the soil should be rested for at least a year before replanting. During this time it should be "cultivated," *i. e.*, frequently stirred to break up and ærate the soil. Lime should also be added where available as it is likely to hasten the death of any remnants of the parasite left after removing the roots. Quick-lime is better for this purpose than slaked lime.

3. *The application of manures or other substances to the roots of diseased palms.*—A few remedies have been tried by cultivators in various places. As, however, almost all were attracted by the unhealthy condition of the crown and did not think of searching for its cause at the roots, these applications were made, for the most part, to the top of the palm. Some used ashes and lime, others Maravetti (*Hydnocarpus Wightiana*) *poonac*, without effect. Lime was applied to the roots in a few cases and appears to have met with, at any rate temporary, success.

This line of work deserves to be followed up. It is possible that the application of lime or some other substance to the roots may enable new roots to be put out and escape attack, by destroying the parasite in the soil. There is an Agricultural Inspector attached to the Experimental Farm at Trivandrum, and this appears to be work which he could carry out. A small garden with sufficient moderately diseased palms for experimental purposes might be taken up and a series of experiments planned with the ordinarily available manures, supplemented by ammonium sulphate, lime, sulphur and sulphate of iron. Each of these should be tested separately, not in combinations.

4. *Improving the general [illegible] of the palm.*—Cultivation in cocoanut lands might be very greatly improved. This is [illegible]cularly the case in the inland districts, such as Minachil Taluk. In these manuring is pr[illegible]d only to a limited extent; drainage is wholly unattended to; cultivation is neglected. The [illegible]mon condition in the badly diseased gardens along the banks of the Minachil river is a d[illegible] undergrowth of weeds and low jungle, through which the palms grow as best they can. [illegible]re is no drainage, though the land is low-lying, heavy, and in urgent need of it. Drain[illegible] these lands would materially improve the root development and give the plant a cha[illegible]rowing out new feeding roots to replace those destroyed. The great root development of palms on the coast soils is probably the reason why they are less severely affected by the disease.

The presence of a dense covering of weeds on the soil keeps the latter badly aerated and probably promotes the growth of the parasite. Cultivation would break up the soil and may be expected to produce a directly harmful effect on the parasite, apart from improving root development.

The effect of manuring on the disease should be studied. It is certain that anything that stimulates the growth of the palm will improve its resistance to the disease. It is, however, possible that some manures, such as cattle manure or other nitrogenous fertilizers, may also stimulate the growth of the parasite and might do so to an extent that would more than counterbalance the improvement of the palm.

5. *Search for disease resistant varieties.*—A number of varieties of the cocoanut palm are known. Several are enumerated in Ferguson's Ceylon Manual, "All about the Cocoanut Palm." I was not able to ascertain what varieties are recognised as distinct in Travancore nor whether any have shown powers of resisting the disease. Enquiries amongst intelligent growers might elicit valuable information in this direction. It is well known that some varieties of a plant often resist disease much better than others, and if such a variety could be discovered amongst the cocoanut palms of Travancore its value would be very great.

6. *Measures to prevent the introduction of the disease to neighbouring territories.*—There is a very large water-borne trade in cocoanut produce with the neighbouring State of Cochin. Intercourse with the British districts of Coimbatore on the north-east and Tinnevélly on the east is less, and there is probably little export of raw cocoanut produce elsewhere than to Cochin. As the latter is a large cocoanut grower and adjoins on the north the extensive cocoanut districts of British Malabar, it appears that stringent regulations are required to prevent the infection of these areas. For practical purposes it is probable that a sufficient safeguard would be provided by prohibiting the entry of living cocoanut plants (seedlings are, it is believed, sometimes exported) and of roots (said to be used for fuel by metal workers, and also as medicine). I am strongly of opinion that the export of these should be forbidden in Travancore and that all coming from Travancore should be declared contraband by Cochin. From the nuts, coir, oil and, in fact, all the aboveground parts of the tree no danger need be apprehended.

Minor disease of cocoanut palms in Travancore.

The following notes on some other diseases of cocoanuts observed in Travancore are added to enable them to be distinguished from that described above. They are at present of less importance than the latter, though in the aggregate responsible for a good deal of damage. As their causes and treatment are different in each case, it is necessary to be able to recognise them wherever active measures against cocoanut disease are proposed.

1 *Leaf-disease caused by Pestalozzia palmarum.*—This disease is due to a fungus which attacks only the leaves. It first becomes visible on the appearance of little transparent whitish spots on the leaves. These may be only few in number or may, in bad cases, be very numerous. They gradually increase in size and become at first yellowish and then white in the centre. As they grow, two or more frequently run together, leading to large irregular areas of dried-up tissue on the leaf. The margins of the leaf often dry in this manner and, as the dead parts crack and fall off easily, the leaflets become ragged along the edges. Around each spot is a dark brown line, outside which is a ring of pale green or yellow tissue, where the healthy part of the leaf is being invaded by the fungus.

The chief differences between the root disease and this are that in the former a large part of the leaf turns pale and then yellow, without the formation of definite white spots; the ends of the leaflets droop and wither but turn brown instead of white at the tips and edges, and do not become ragged; the central shoot is stunted and eventually withers from above downwards, whereas in the leaf disease the central shoot is little affected, except in bad cases.

A few spots of leaf disease are common on cocoanuts all along the Malabar coast. In young gardens it may become a serious blight, as young palms are more affected than old. In one garden, where the palms were about seven years old, the appearance from a distance resembled that produced by root disease, but closer examination showed no trace of the latter. There was no drooping of the leaf ends; all the leaves were dotted with white spots surrounded by a yellow ring, so close together that the leaves looked quite yellow from a little distance.

Severe outbreaks of this disease have been reported from Java and elsewhere. They have only occurred on young trees and except in the latter the fungus does not appear to do much harm. It is worst in Travancore on neglected young palms and in the garden referred to above an application of manure had resulted in a marked improvement. Cultivation and manuring appear to be all that are required in most cases for its checking.

2. *Bud rot caused by Pythium palmivorum.*—At Changanachery a few cases of this disease in cocoanuts were seen. It is the cause of the Godavari palmyra palm disease, and in the latter district attacks cocoanut and areca palms also, though less severely than palmyras. A general description of the Godavari disease has been published in the Agricultural Journal of India, Vol. I, Part 4, October 1906, and a technical account of the parasite in the Memoirs of the Department of Agriculture in India, Vol. I, No. 5, February 1907. The withering of the central shoot at an early stage of the disease is the most characteristic feature and serves to distinguish it from root disease, in which the central shoot is only affected at a late period.

The first external symptom is the turning white of an entire leaf, usually towards the center of the crown. This is rapidly followed by a similar discoloration of the central shoot or unopened leaf that stands up in the centre of the crown. After a short time the central shoot rots and eventually the whole crown falls off. This is accompanied by an extreme degree of putrefaction,

the whole "cabbage" becoming converted inside into a foul-smelling, putrid mass. The palm may be killed in a few months, so that the attack is much more virulent than in root disease. Recovery is very rare.

On the young unopened leaf blades and the white leaf-bases in the "cabbage," brown spots with a distinct margin will be found. These are covered with a white felt of fungus threads. In Changanachery, *Pythium palmivorum* was found producing its characteristic spores on young leaf blades of cocoanut in the unexpanded stage of the bud. The "cabbage" was so rotted that only small fragments of the fungus could be found elsewhere than on the blades The affected trees were doomed as the apical growing point was affected.

There is no remedy once the centre of the crown is reached. To save neighbouring palms from infection it is necessary to cut of and burn the diseased crown as soon as one or more internal leaves are observed to have withered. This should be done promptly as the disease is highly infectious and is a very dangerous one.

3. *Insect attacks.*—The two well-known large insects which attack cocoanut palms, the black beetle or rhinoceros beetle and the red beetle or palm weevil, are common in Travancore. Only the latter's attacks are liable to be mistaken for root disease and that only exceptionally. In a few cases the weevil attacks the "cabbage" in such a manner as to cause several of the central leaves to turn yellow. These, however, dry up simply because they have been partly eaten through at the base, and consequently they can be easily pulled out, when the cause of the injury will be evident. Most palm climbers will tell at once by examining an affected crown whether it is due to weevil or not, as all are familiar with the white fat grub an inch or two long and with the damage it causes. The black or rhinoceros beetle is common on diseased as well as healthy palms, and its effects may be easily recognised by the ragged appearance of the leaves of attacked trees. These are often partly eaten through while still folded within the bud and, after expanding, a symmetrical portion of the leaf or of a few leaflets is found to have been bitten off.

A scale insect occurs on the leaves in some localities and produces a yellowing which might be mistaken on a superficial examination for root disease. It is easily recognised on turning over the leaf, when numerous colonies of a small brown insect, closely fastened to the under surface of the leaf, will be found.